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The effects of sensory integration techniques on muscle tone in children after prenatal exposure to alcohol

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ABSTRACT

Background: Prenatal exposure to alcohol is the cause of Foetal Alcohol Syndrome (FAS). Alcohol exerts an especially negative effect on the central nervous system of an unborn child. Children with FAS frequently have problems with sensory integration. The objective of the study was an evaluation of the effectiveness of SI therapy in children with Foetal Alcohol Syndrome on the example of muscle tension. **Methods:** The study was conducted in 2012 at the Centre of Advanced Physiotherapy in Kielce, and covered a group of 20 children aged 4-5 who had a history of prenatal exposure to alcohol. The children systematically participated in a one-hour SI therapy session, once a week for the period of 6 months. **Results:** A high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol based on the example of muscle tension ($p<0.001$). The positive effects of therapy were proved for the following tests: in prone extension position ($p<0.001$), in supine, flexed position ($p<0.05$), ATOS ($p<0.001$), STOS ($p<0.001$), the Schilder test ($p<0.001$) and trunk stabilization ($p<0.001$). **Conclusions:** The sensory integration technique exerts a beneficial effect on the normalization of muscle tone in children after prenatal exposure to alcohol.

Key words: therapy using sensory integration technique, muscle tone, prenatal exposure to alcohol

INTRODUCTION

Foetal Alcohol Syndrome (FAS) is the consequence of the effects of alcohol on the foetus during the prenatal development period [1]. Alcohol has an especially negative effect on the central nervous system of an unborn child [2,3]. It also results in abnormalities in physical development (face, lips, eyes, body size), difficulties in cognitive development, behavioural disorders, memory deficits and ADHD syndrome [4,5]. FAS is the sum of abnormalities in physical and mental development, resulting in challenges for the future development of a child, as well as for parents and society [6,7]. It is characterized by psychophysical disorders in the form of mental retardation, brain dysfunction, abnormalities in general development, psychomotor and physical abnormalities, disorders in learning and shaping personality [8,9]. Children with FAS often experience problems with sensory integration [10,11]. A child with SI disorders may behave in a strange way, incomprehensible for the environment [12,13]. If the child incorrectly receives and processes tactile stimuli, s/he may hate hair-washing, may pat or scratch without evident reason, fidget in a chair, avoid close contact or demand this contact more often than peers [14,15]. If any abnormalities occur in the vestibular system responsible for balance reactions, the child may be afraid of stairs, dislike swings, seek assistance when the ground changes, or to the contrary, perform locomotor manoeuvres which make others dizzy or sick by just looking at them [16]. With abnormal proprioceptive sensations, the child may maintain in constant motion: running instead of walking, jumping instead of sitting or may assume very strange positions [17]. Muscle tone is a constantly maintained state of contraction of the muscles, which is affected by many factors – mainly one's own response of the muscle to stretching [18]. The physiological mechanisms exerting an effect on the regulation of the tone are very complex [19]. The most important receptors

related with muscle tone are proprioceptors. They include a neuromuscular spindle (in muscles) and Golgi organs (in tendons). Contraction of a muscle causes an increase in its tone, which stimulates the spindles and Golgi organs. In this way, a closed circuit is created, spontaneously evoked by impulses from the nerve endings [20]. Apart from the above-mentioned feedback, muscle tone is also affected by impulses constantly flowing from the cerebral cortex and subcortical nuclei. Their action consists mainly of the inhibition and regulation of muscle excitability. Normal muscle tone should be high enough to be able to resist the force of gravity, and low enough that the movements can be freely performed [21]. Physiological muscle tone may differ and assume lower or higher values. Abnormal muscle tone impairs the psychophysical development of a child [22]. The objective of this study was an evaluation of the effectiveness of SI therapy in children after prenatal exposure to alcohol, based on the example of muscle tone.

MATERIAL AND METHOD

The study was conducted in a group of 20 children (6 girls and 14 boys), aged 4-5 years, with a history of prenatal exposure to alcohol. The majority of children came from adoptive and foster families or orphanages. The study was conducted in 2012 at the Centre of Advanced Physiotherapy in Kielce (Poland). All procedures performed in tests involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The guardians of the children were informed about the purpose of the study and expressed written consent for their children's participation in the study. The study was non-invasive and free of charge. The patients willingly participated in the study and perceived it as a concern about their state of health. All children were diagnosed with SI disorders and dysfunctions typical of children with FAS spectrum, including: hyperactivity, pertinacity, passiveness, impulsivity, sleep problems, malice, hypersensitivity to touch and sound, adaptation difficulties, problems with organization, low self-esteem, difficulty with self-control and ease of falling into depressive states. The examination of sensory integration disorders consisted of three 50-minute diagnostic meetings. The diagnosis of SI included: an interview with a parent/caregiver, observation of controlled and spontaneous movements of the child in the therapeutic room, response to the basic sensory stimuli administered, as well as clinical observation. The evaluation included gross and fine motor skills, muscle tone and balance responses of the body. The presented study comprehensively discusses the effect of SI on muscle tone. While evaluating muscle tone, 8 trials with clinical observations were performed according to Ayres: cocontraction, prone extension position, supine flexed position,

ATOS, STOS, muscle tone, the Schilder test and trunk stabilisation. Each child systematically participated in a one-hour SI therapeutic session once a week for 6 months. The therapeutic programme covered: normalization of the vestibular, proprioceptive and tactile systems, normalization of muscle tone, development of motor planning, oculomotor performance and motor coordination, hand therapy, integration of ATOS, STOS, development of locomotion and balance functions, as well as improvement of the efficacy of gross and fine motor skills. Measurement data were collected using the Microsoft MS EXCEL spreadsheet, and after preliminary processing, imported to Statistica StatSoft software. Data analysis included anthropometric characteristics (height, body mass, BMI) and tests for SI. Basic statistical parameters were calculated, such as: arithmetic mean (x), standard deviation (s), median value (Me), skewness (Sk), and kurtosis (Ku), as well as extreme values and confidence intervals for the level of 95%. The variables were verified from the aspect of normality of distribution using the Shapiro-Wilk test. In addition, Cronbach's Alpha analysis of reliability was also performed. In order to reveal the differences between studies prior to and after SI therapy, the Student's *t*-test and the Wilcoxon matched pairs test were applied.

RESULTS

The mean age of children was (x = 4.45), standard deviation (s = 0.51); mean body height (x= 1.01), standard deviation (s = 0.03); body mass (x = 16.35), standard deviation (s = 1.34); mean BMI (x = 15.73), standard deviation (s = 0.52) (Tab. 1).The mean result in the test for co-contraction was the same prior to and after SI therapy and was 1.000; the mean result in the prone extension position was 0.700 before therapy and 0.900 after SI therapy, the difference 0.290; the mean result in the supine flexed position was 0.888 before therapy and 0.988 after SI therapy, the difference 0.100; the mean result in the ATOS test was 0.350 prior to therapy and 0.500 after SI therapy, the difference - 0.150; the mean result in the STOS test was 0.700 before therapy and 1.000 after SI therapy, the difference -0.300; the mean result for muscle tone was 0.850 before therapy and 0.850 after SI therapy; the mean result in the Schilder test was 0.4170 before therapy and 0.717 after SI therapy, the difference - 0.300; the mean result for trunk stabilisation was 0.500 before therapy and 0.767 after SI therapy, the difference 0.267; the overall result of muscle tone was 0.676 before therapy and 0.851 after therapy, the difference - 0.176 (Tab. 2). A non-significant result of the Shapiro-Wilk test confirmed that the distribution of the observed variable (muscle tone) was similar to normal distribution both prior to (p = 0.291) and after therapy (p = 0.118). The Cronbach's Alpha coefficient assume values from 0-1. The higher the value, the higher the reliability of the scale. It is assumed that values of over 0.7 mean the acceptable reliability of the scale.

Analysis of Cronbach's Alpha coefficients showed a high reliability of the applied tests, especially prior to therapy. The high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol, based on muscle tone. Positive outcomes of SI therapy were obtained for the following tests: in prone extension position ($p<0.001$), in supine flexed position ($p<0.05$), ATOS ($p<0.001$), STOS ($p<0.001$), the Schilder test ($p<0.001$) and trunk stabilisation ($p<0.001$). The Student's *t*-test for muscle tone in the case of normalized values showed significant differences in tests conducted prior to and after SI therapy ($p<0.001$) (Tab. 3).

DISCUSSION

The report by the Birth Defects Monitoring Program conducted by the Centers for Disease Control (CDC) based on data from 1,500 hospitals showed that the incidence of the cases of FAS in the American population is 0.3-0.9 per 10,000 births [23]. In turn, Abel and Sokol, after reviewing 19 epidemiological reports from the whole world, estimated the incidence of FAS at 1.9 per 1,000 live births. According to the CDC reports, the rates of occurrence of FAS per 10,000 births differ according to the ethnic origin of their mothers. The incidence of FAS worldwide is estimated at 3-9 per 1,000 live births [24]. Knuiman, Rijk, Hoksbergen et al. [25] examined a group of children adopted from Poland by Dutch parents. The study included 121 children aged 6-17. Three groups were distinguished: children with the diagnosis of FAS (31%), children whose adoptive parents suspected FAS (21%), and children whose adoptive parents did not suspect FAS (49%). In children with the diagnosis of FAS, body height insufficiency was observed. The children attended special needs schools and had difficulties with social functioning. However, the features of FAS were also observed in the other two groups. Children adopted from Poland showed a high risk of FAS. The researchers presumed that the Dutch adoptive parents must have realized the potential consequences of prenatal exposure to alcohol in children adopted from Poland. It is estimated that in Poland, there are 900 cases of fully symptomatic FAS in infants annually, whereas, in 9,000 children, the occurrence of some of its symptoms is observed [25]. The study conducted at the Institute of Mother and Child in Warsaw, consisting in the examination of urine samples in pregnant women who declared abstinence for the presence of markers of alcohol consumption (beta-hexosaminidase and gamma-glutamyltranspeptidase), showed that every third woman consumed alcohol knowing that she was pregnant [26]. A survey carried out at 2005 in the Sopot Laboratory for Social Studies by order of the State Agency for the Prevention of

Alcohol-Related Problems (PARPA) in a representative group of 1,038 women at the reproductive age of 18-40, showed that every third woman consumed alcohol during pregnancy [27]. Alcohol was most frequently consumed by women with secondary school education, while most rarely by those with primary school education. The highest consumption of alcohol was observed among women from small and medium-size towns, whereas the lowest – among those from large cities and rural areas. In 2005, the IBSOS International Research Group Laboratory, by order of the Childbirth with Dignity Foundation, conducted a survey in a representative group of 1,000 Poles aged 15 and older. One-third of the women (33.5%) who had given birth to one or more children admitted that they had consumed small amounts of alcohol during pregnancy. Although 83% of respondents had heard that even the smallest amount of alcohol may be dangerous, one-third of them (31.7%) mentioned that a small amount of alcohol may exert a positive effect on the mother and child. The prepared expertise, based on an all-Polish survey in 2009, showed that 29% of women consuming alcohol within the previous year were pregnant [28]. The effects of ethyl alcohol on the foetus still remain a poorly described and recognized problem. In children whose mothers consumed alcohol, problems with functioning difficult to diagnose and classify are observed, as well as sensory integration disorders [29,30]. For these children, effective SI therapy is necessary. The objective of my other studies was an analysis of the effect of SI therapy on gross motor functions in children after prenatal exposure to alcohol. Positive effects of SI therapy were observed for the following tests: finger to nose, in the prone extension position, in supine flexed position, ATOS, STOS, the Schilder test, dynamic balance, static balance, gravitational insecurity and trunk stabilisation. The effectiveness of SI therapy was not confirmed only in the tests for cocontraction and muscle tone [31]. In my other studies, the effect of SI on fine motor functions in children after prenatal exposure to alcohol was analysed. The high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol based on fine motor functions ($p<0.001$). The positive effects of SI therapy were proved for the following tests: quick rotation of the forearms ($p<0.001$), eye movements ($p<0.001$), fingers to a thumb and in prone extension position ($p<0.001$) [31]. The author of the presented report also investigated the effect of SI on the balance system. A high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol on the example of the balance system. Positive results of SI therapy were confirmed for the following tests: Schilder ($p<0.001$), dynamic balance ($p<0.001$), static balance ($p<0.001$), gravitational insecurity ($p<0.001$) and post-rotatory nystagmus ($p<0.05$) [32,33]. Similar results of therapy were obtained in studies on children with developmental deficits from

Kielce (Poland). The study covered a group of 153 children admitted for therapy at the third year of life. The objective of the study was an analysis of the effect of sense integration: mainly proprioception, the vestibular system on vocabulary development. The presented results of the performed diagnoses of the sensor integration processes indicate that the most impaired areas are related with static and dynamic balance, as well as post-rotatory nystagmus. They also indicate considerable disorders in the development of the vestibular system Early diagnosis of sensor integration disorders in the population examined can, to a great extent, prevent more serious problems in the development of children. Disorders in the processes of sensor integration hinder the normal development of speech and language. The greatest deficits in the sphere of vocabulary development were noted in the area of creating subwords, and defining concepts in combination with dynamic and static balance disorders. In addition, a relationship was observed between vestibular system disorders and acquisition of skills with respect to vocabulary [34].

CONCLUSIONS

The high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol on the example of muscle tone. Statistically significant results of SI therapy were proved for the following tests: in the prone extension position, in supine flexed position, ATOS, STOS, the Schilder test and trunk stabilisation. Analysis of Cronbach's Alpha positions showed a high reliability of the applied SI tests, especially prior to therapy. The sensor integration technique (SI) exerts a beneficial effect on the normalization of muscle tone in children after prenatal exposure to alcohol.

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Table 1. Anthropometric data of children in the study.

Variables	N	Mean	Median	Minimum	Maximum	SD	Skewness	Kurtosis
Age	20	4.45	4	4	5	0.510	0.218	-2.183
Body height	20	1.0185	1.02	0.94	1.08	0.036	-0.393	-0.228
Body mass	20	16.35	16	14	19	1.348	0.283	-0.771
BMI	20	15.738	15.893	14.704	16.340	0.527	-0.671	-0.666

Table 2. Muscle tone before and after SI therapy.

Muscle tone prior to SI therapy						
Tests for muscle tone	N	Mean	Median	Minimum	Maximum	SD
Test for cocontraction	20	1.000	1.000	1.000	1.000	0.000
Test in prone extension position	20	0.700	0.700	0.200	1.000	0.178
Test in supine flexed position	20	0.888	1.000	0.250	1.000	0.190
Test for ATOS	20	0.350	0.333	0.333	0.500	0.051
Test for STOS	20	0.700	0.667	0.667	1.000	0.103
Muscle tone	20	0.850	1.000	0.667	1.000	0.170
Schilder test	20	0.417	0.333	0.000	0.667	0.183
Trunk stabilisation	20	0.500	0.667	0.000	1.000	0.296
Muscle tone - overall result	20	0.676	0.692	0.390	0.896	0.120
Muscle tone after SI therapy						
Tests for muscle tone	N	Mean	Median	Minimum	Maximum	SD	Difference
Test for cocontraction	20	1.000	1.000	1.000	1.000	0.000	0.000
Test in prone extension position	20	0.990	1.000	0.800	1.000	0.045	0.290
Test in flexed supine position	20	0.988	1.000	0.750	1.000	0.056	0.100
Test for ATOS	20	0.500	0.500	0.500	0.500	0.000	0.150
Test for STOS	20	1.000	1.000	1.000	1.000	0.000	0.300
Muscle tone	20	0.850	1.000	0.667	1.000	0.170	0.000
Schilder test	20	0.717	0.667	0.667	1.000	0.122	0.300
Trunk stabilisation	20	0.767	0.667	0.333	1.000	0.244	0.267
Muscle tone - overall result	20	0.851	0.854	0.715	0.938	0.057	0.176

Table 3. Wilcoxon matched pairs test for muscle tone.

Tests for muscle tone	Initial examination		Final examination		Difference	Wilcoxon test
	N	Mean	N	Mean		p
Test for cocontraction	20	3	20	3	0	-
Test in prone extension position	20	3.5	20	4.95	1.45	<0.001
Test in supine flexed position	20	3.55	20	3.95	0.4	<0.05
Test for ATOS	20	2.1	20	3	0.9	<0.001
Test for STOS	20	2.1	20	3	0.9	<0.001
Muscle tone	20	2.55	20	2.55	0	-
Schilder test	20	1.25	20	2.15	0.9	<0.001
Trunk stabilisation	20	1.5	20	2.3	0.8	<0.001

Student's *t*-test for muscle tone prior to and after SI therapy (n = 20)

Mean	SD	Difference	SD Difference	t	df	p	Confidence	Confidence
0.851	0.057						-95.00%	95.00%
0.676	0.120	0.176	0.075	10.444	19	0.001	0.141	0.211